PROJECT 9 OVERVIEW
Exploring Options for Using Technology in Data Collection

INTRODUCTION

The U.S. Department of Transportation (DOT) maintains over 40 programs that capture either safety data or crucial related information (e.g., measures of exposure). A recent data quality review requested by Congress suggests that improvements can be made that will better serve the DOT mission.

The objective of this project is to explore options for using technology to facilitate more timely data collection, improve data quality, and assure the relevance of transportation safety data. This overview briefly describes the project's background, methods, results, and recommendations. The project's final product is a prioritized set of work plans identifying promising technologies for field-testing.

Background

DOT's safety mission extends to all modes of transportation: air, highway, commercial trucks and buses, rail, pipeline, and waterway. In each of these modes, data-collection technologies have enhanced the ability of each agency to collect key safety data in a timely and accurate fashion. This project identifies new applications of existing or emerging technologies for further testing across the modes.

Each of the modes within DOT is engaged in technology projects, many of which relate directly to data collection and the safety mission of their administration. There are some commonalities in the types of technology being used, most notably in the area of event data recorders in vehicles and the use of global positioning systems (GPS) and geographic information systems (GIS) for obtaining and analyzing location information.

As a starting point, the Volpe National Transportation Systems Center compiled a listing of some existing data-collection projects within DOT that utilize technology at some level. There are a large number of ongoing technology projects within DOT. Some of these technologies are already in use in more than one mode. The Project 9 research team identified additional data-collection technologies.

Objectives

The objectives of this project were to identify potential uses of technology to:

- improve the timeliness of basic data collection,
- improve the accuracy of data collected,
- improve the usefulness of the data collected,
- improve the cost-effectiveness of the data-collection system overall, and
- establish or increase utilization of technology across transportation modes.

Scope

Project 9 was primarily centered on two activities: 1) identifying existing technologies already used in one mode that could have potential application to data collection for other modes; and 2) identifying "new" technologies for safety data collection. The sources of new technologies were defined as any non-DOT entity including other government agencies and the private sector. DOT modal experts also identified candidate technologies that might have an innovative application for their mode. The experts wrote descriptions of technologies and expanded the list to include additional projects that, in their judgment, could provide important safety data either in their mode or in another DOT mode.

GENERAL APPROACH

This project solicited input from the various modes of transportation about uses of technology for Data-Collection Elements. Of particular interest were those technologies that could be pilot tested or implemented in one mode and then the results transferred for use by one or more other modes. This section of the report outlines how each of these tasks was conducted.

Data Collection Issues and Potential Technologies

As part of the Bureau of Transportation Statistics (BTS) SDI work group sessions, modal representatives described data-collection issues faced by specific program areas within their administration. A subset of these data-collection issues had clear safety implications for the mode. As such, they were useful in the effort to identify a preliminary set of data-collection issues for each of the modes.

The DOT modes, as well as state and local government agencies, are engaged in a large number of data-collection technology projects. As detailed in the Background Section of this overview, the Volpe Center provided descriptions of data-collection technologies currently in use that cover a broad range of applications. Modal experts in each of these applications were identified and contacted by BTS staff. The experts were asked to describe the technology in sufficient detail to enable project team members to decide whether it had potential application to identified Data Collection Elements needs. Experts were also asked to comment on the potential applicability of selected technologies to other data-collection needs, both within and outside their mode. This effort resulted in a list of existing technologies and additional information on other areas where those technologies might be applied for data-collection.

Technology Transfer Opportunities

Experts in each of the modes were asked to provide contacts outside of DOT who are using or developing technologies that might be applicable to Data-Collection Elements inside DOT. These contacts were drawn from industry and other government agencies (federal, state, and local government, as well as foreign governments' transportation agencies). Further contacts were identified through these initial industry and other government agency contacts, web-based searches, and business-to-business listings. Each of the contacts was asked to provide descriptions of technologies in sufficient detail that the project team could decide whether the technology had potential application in addressing Data Collection Elements needs in DOT.

Technology Prioritization

The tasks described above produced a substantial list of new and existing technologies with cross-modal transfer potential. These technologies were evaluated in order to develop a set of proposed technology projects for Work Group B prioritization. In order to develop the technology projects for prioritization the project team grouped the technologies into eight general categories. Within each of the categories, several example projects were described. The following criteria were used to evaluate each project:

- *Cost-effectiveness*: A statement of whether the project promises a reasonable "return on investment" in that the savings (cost reductions, lives or resources saved) are demonstrably larger than the costs of implementing the project.
- *Feasibility:* A statement of the likelihood that the technology can be implemented as described and the likelihood that, as implemented, the technology will meet the functional specifications.
- *Likely impact*: A statement of the concrete changes that will occur once the technology is implemented (improved data quality, timeliness, accessibility of the data).
- *Anticipated cost*: An estimate of the cost of implementation of the technology at the level or extent required to achieve the desired outcome.
- *Maintainability*: A statement of the projected, annualized maintenance costs for a "standard" implementation of the technology, and, where needed, a qualitative assessment of the ability to maintain the technology once installed.
- *Potential for expansion and/or new applications*: A statement of the probable further uses for the technology, should it prove successful in the evaluation project. Does the technology have the potential to add new features and/or new operating characteristics?
- *Accessibility*: A statement of the level of technical expertise required to operate and/or maintain the technology in a manner that will maximize the benefits of the implementation. High accessibility means that a low level of skill or training would be required to keep the technology functioning as desired.
- *Strategic importance*: Reviewer's judgment of how well this project fits with the agency's strategic plan and mission.
- *Adaptability*: Reviewer's judgment of how well this technology fits with

existing technology projects in the agency.

- *Cross-functional application*: Reviewer's judgment of further applications of this technology within their mode.
- *Industry buy-in*: Reviewer's judgment of how this technology project would be perceived by the affected industries.

In order to prioritize the technologies, Group B members were asked to read the general description of each technology type, review each of the several example implementation descriptions, and then simply rank order the eight technologies based on the needs of their own mode for safety data collection. The participants were encouraged to use the example descriptions to help determine the value of the technology to their mode.

EVALUATION OF THE EIGHT MOST PROMISING DATA COLLECTION TECHNOLOGIES

The Work Group B members selected the following eight technologies, in order of priority:

- Electronic Identification/Security (Smart Cards),
- Operator Performance Monitoring,
- Hands-Free Operation (wearable computers for data collection),
- Vehicle Usage Monitoring Systems,
- Imaging (x-ray, mm-wave, and satellite),
- Voice-Activated Data Input,
- Automated Control Device Data Collection,
- Pattern Recognition Software.

Each of these technologies is described briefly in the following eight sections. Some potential data collection elements that may depend on a specific application and/or interface with other technologies are also listed for each technology.

Electronic Identification/Security (Smart Cards)

Smart cards are credit-card size devices with embedded memory circuits. The devices can be written to or read using a simple, inexpensive computer interface. Smart cards are currently being tested for use as credit/bank cards and potentially in some driver licensing applications. The maritime industry uses these devices now for tracking training and qualifications.

Smart cards offer the potential for increased security by incorporating biometric information on the owner of the card that can be checked against the same measures taken from the person attempting to use the card. The most promising of these biometric data sources include thumbprints and retinal prints. Implementation involving thumbprints is the simpler and less expensive of the two options.

Some potential data-collection elements:

- user identification;
- date, time, start, end, and route of travel;
- speed, lane keeping, following distance, and other performance measures;
- waiting times;
- vehicle configuration;
- way points;
- time at controls; and
- user qualifications and experience.

Operator Performance Monitoring

Checking employees' readiness for service can be accomplished using technologies that: a) require a pre-test before operation and/or b) provide ongoing monitoring or feedback on performance during operation. Such systems are in place aboard some ships and have been tested in commercial motor vehicles (e.g., lane departure warning devices for detecting drowsy drivers). The primary goal of such systems is to provide feedback to the operator in order to improve safety by alerting them to lapses in concentration. The systems could also be used to collect data on the prevalence of selected types of operator behaviors.

Some potential data-collection elements:
- user readiness to perform;
- user reaction time to hazard warnings;
- control movements in response to specific events;
- lane departures, speed, following distances; and
- accuracy of identification on simulated objects throughout the workday.

Hands-Free Operation

Many transportation activities occur away from a desk or vehicle, for example, inspections, assessment, or enforcement duties. The usefulness of hand-held computers is limited by their size and the need for the operator to hold the device in one hand in order to use it with the other hand. There are computing devices integrated into uniforms or outer safety garments (e.g., safety vests) that may support these field data-collection activities in a much more natural way. The device may include a small ocular "screen" for display of information visually, a voice input/output device, a small keyboard strapped to one arm, and various accessories such as GPS, bar code readers, smart card readers, magnetic stripe readers, and communications devices for sending and receiving data via radio, cell phone, or other method.

Some potential data-collection elements:
- standard law enforcement reports, and
- data entry for numerous safety data elements.

Vehicle Usage Monitoring Systems

As an advancement over Event Data Recorders now found in commercial aircraft, trains, ships, and motor vehicles, usage monitoring systems would serve to collect additional data elements not currently available. For example, collecting data on the user of the vehicle could ensure that only authorized personnel can operate a vehicle or perform a particular task onboard the vehicle. Collecting information on the route taken, speeds reached, and start/end points of trips would be useful in surface transportation modes. Links to other onboard systems (e.g., hazard indicators and telemetry systems) will allow the storage of data on operators' response to incidents or near-incidents.

Some potential data-collection elements:
- user identification;
- route taken, starting point, and ending point; and
- time and date of travel via computer-based clock/calendar.

Imaging

Imaging capabilities have expanded and the costs of the data have begun to drop in recent years. Satellite imaging systems already in existence can identify moving objects with a high degree of reliability and millimeter wave imaging systems that can detect plastics underneath clothing. These systems have obvious applications in security in all modes and for use in system performance monitoring for traffic control.

Some potential data-collection elements:

- traffic volume, vehicle classification;
- speed, delay;
- origin/destination and duration of travel;
- incident response;
- platooning of traffic;
- ramp metering and intersection signal control optimization;
- location, duration, and extent of event;
- time to first response;
- progress of response;
- concealed object identification; and
- image database for developing pattern recognition software.

Voice-Activated Data Input

Data collection, especially in adverse environments, has benefited recently from advances in real-time voice interface technology. Essentially, this technology allows a user to enter data or perform functions on a computer by speaking into a microphone. Computer software analyzes the speech and interprets the resulting words as data, text, or commands. In the simplest applications, a limited vocabulary is used in order to increase the accuracy of translation. Broader applications (e.g., word processing or spreadsheet-type software) must allow for an unlimited vocabulary, and thus the capacity for the translation software to "learn" both the speaker's vocal mannerisms and new items in its dictionary of terms or commands. In conjunction with event data recorders and intelligent transportation system technology, voice data input has numerous applications from simple replacement of keyboards for data entry in adverse environments to enhanced security for command and control situations.

Some potential data-collection elements:

- user identification;
- route taken, starting point, and ending point;
- time and date of travel;
- control inputs;
- comparison of control inputs to actual operation;
- presence of hazards; and
- response to events.

Automated Control Device Data Collection

A variety of automated control devices are now planned or in operation across the DOT modes: a remote control system for commercial aircraft is being tested, automated ships are already in use in the maritime industry, and motor vehicle automated control systems are being testing by various manufacturers. The common denominator for all of these systems are data requirements for making the software-based decision of when to take control and for operating safely in automated modes.

Some potential data-collection elements:

- user identification;
- speed changes;
- travel position;
- logged travel course;
- type of aircraft, vehicle, ship;
- behaviors leading up to event;
- successful and unsuccessful avoidance maneuvers; and
- identification of specific hazards.

Pattern Recognition Software

Pattern recognition software is a class of software designed to identify target "items" from a stream of data in real time. Variants of this type of software are programmed to deal with images (e.g., sorting applications, facial recognition), auditory patterns (e.g., speech recognition, looking for key phrases), or even odors (e.g., molecule detection systems). All of these systems involve the programming of a particular pattern to be searched for from among an incoming stream of data. When the system detects that pattern (or one labeled “similar enough” through a set of “fuzzy” algorithms), the software can alert users to the presence (or probable presence) of the target item, whether that item is a person, a weapon, or a spike in fluid flow readings.

Some potential data-collection elements:
- object identification and profiling;
- enhanced assistance to screening personnel;
- concentrations of specific substances; and
- flow rates, variations in environmental factors.

RECOMMENDATIONS

The first three technologies listed in the previous section (Electronic Identification/ Security Smart Cards, Operator Performance Monitoring, and Hands-Free Operation) clearly had the most support from all the modes surveyed. This indicates broad possibilities for application of these technologies. It is recommended that at least one, if not several, pilot projects be developed in these three technology areas. The examples provided in the final report should provide a good starting point. The remaining five technologies each have support from at least one mode, indicating that these might be worth a single project as a proof of concept and/or to develop the idea further for the other modes to review. It is recommended that BTS and the mode(s) that supported these technology ideas work together to develop a single pilot project of each technology. Statements from the Group B participants in support of or critical of the application of each of the technologies are included in the Recommendations Section of the final report.